UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MODEL STUDY FOR THE REVISION OF THE STILLING POOL APRON--GILA VALLEY DESILTING WORKS AT IMPERIAL DAM--GILA PROJECT, CALIFORNIA

Hydraulic Laboratory Report No. Hyd-344

ENGINEERING LABORATORIES BRANCH

DESIGN AND CONSTRUCTION DIVISION
DENVER, COLORADO

January 30, 1952

CONTENTS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Design and Construction Division
Engineering Laboratories Branch
Denver, Colorado
January 30, 1952

Laboratory Report No. Hyd-344
Hydraulic Laboratory Section
Compiled by: Yin Feng
Checked by: J. N. Bradley
Reviewed by: H. M. Martin

Subject: Model study for the revision of the stilling pool apron--Gila Valley desilting works at Imperial Dam--Gila Project, Arizona

INTRODUCTION

This report is an account of a model study performed to obtain information for revision of the sluiceway stilling pool apron at the Gila Valley desilting works.

The Gila Valley desilting works is located on the left bank of the Colorado River at Imperial Dam in Arizona, Figure 1. In general, it consists of a gate structure, one large trapezoidal settling basin, and a combination canal intake and sluiceway structure at the downstream end. Water from the lake behind Imperial Dam flows slowly through the basin, depositing a portion of its silt load on the floor. The canal intake at the downstream end of the basin receives water from the upper level of the basin, while the sluiceway immediately under the canal intake is used to flush the deposited silt back into the river when necessary. The sluiceway does not operate continuously. A plan of the canal intake and sluiceway stilling basin is shown on Figure 2 and sections are shown on Figure 3.

The entire desilting works was operated as intended up until 1944. At that time, the Army was permitted to practice amphibious landing operations downstream from the dam. These operations required considerably more discharge than the normal flow of the river at this point. The Gila Valley settling basin provided a means of storing water, and the sluiceway offered a method of releasing it downstream at discharges much higher than normal for a short period of time.

Neither the settling basin nor the sluiceway stilling pool was designed for this type of operation. However, both structures served the purposes of the Army during and after the national emergency, but not without eventual detrimental effect. In 1949, the floor and side walls of the settling basin heaved in several places from unrelieved uplift pressures, and erosion downstream from the sluiceway stilling pool was reaching dangerous proportions from the large discharges. Holes 18 feet deep were reported at the downstream end of the apron, even though the bed was originally heavily riprapped to resist erosion. Continuation of either the Army or Bureau operations required immediate repairs.

The basin does not pass much over 1,000 cfs during normal sluicing operations. However, the Army was using discharges of as much as 20,000 cfs through this basin. As it was anticipated that the Army would continue operations, repairs were to be expedited and this meant that they would of necessity be of a more or less temporary nature. The object, therefore, was to revise the stilling pool so that it would handle intermittent discharges of 20,000 cfs without doing further damage.

THE MODEL

The existing apron for the sluiceway stilling pool is 50 feet long by 158 feet wide. A sectional model was constructed of the existing structure on a 1:30 scale. The model was 2 feet wide, which represented 60 feet, or a little more than one-third of the prototype width (Figure 4). The stilling pool was constructed of wood and lined with sheet metal, while the piers, gates, and sills were of wood. Gates at the upstream end made it possible to regulate the head. The model was installed in a laboratory flume, having a glass side, through which the action of erosion could be observed. A pot-type gage was installed in the head box for setting the head on the gates, while a similar gage was installed in the tail box to observe the water surface in the river. The maximum discharge used in the sectional model was 1.55 cfs.

EXISTING DESIGN

The tail-water curve for the river downstream from the dam is shown on Figure 5. Superimposed on the same chart is the computed theoretical jump height curve, "A," and a sweep-out curve, "B," for the existing design obtained from the model tests. A third curve, "C," represents 85 percent of the theoretical jump height which is permissible in some designs which use an end sill and/or baffle piers. The jump height curve, "A," and the tail-water curve intersect at a discharge of 8,700 cfs which means that the tail water is less than would be desirable for discharges above this value. The 85-percent theoretical jump height curve, "C," intersects the tail-water curve at a discharge of 12,000 cfs. This indicates that an acceptable jump may form for flows up to 12,000 cfs. The sweep-out curve, "B," intersects the tail-water curve at a discharge of 15,300 cfs which means that a jump cannot form for discharges above this value.

Figures 6 and 7 show photographs of the existing design for discharges of 8,000, 12,000, 16,000, and 20,000 cfs. Figure 6-A shows good operation at a discharge of 8,000 cfs. Figure 6-B shows the jump partially in the pool for a discharge of 12,000 cfs. Thus, more than 85 percent of the thoeretical jump height is required in this case for good operation at 12,000 cfs. The jump swept out of the pool for a discharge of 15,300 cfs. Figures 7-A and -B show the jump out of the pool for discharges of 16,000 and 20,000 cfs, respectively. For a discharge of 20,000 cfs, the tail-water depth was only 65 percent of the theoretical jump height. Figure 8 is a plot of the scour obtained from the model of the existing design after a discharge of 20,000 cfs for 1 hour (model time). The maximum depth of scour is 16 feet.

Since the prototype stilling basin apron had not been damaged by the Army operations, and since operation at discharges greater than 12,000 cfs was unusual, it appeared unnecessary to disturb the present apron which is 3 feet thick. Lengthening the apron could not possibly increase the discharge range over which a jump would form because of the large deficiency in tail-water depth. The problem was, therefore, resolved into finding a means of dissipating the energy in the 20,000-cfs discharge on the present apron by adding sills and baffle piers.

TEST PROCEDURE

The plan to be followed was to place baffle blocks on the existing apron in such a manner that a large portion of the dissipation of energy for discharges up to 20,000 cfs would occur on the apron. Several schemes were tried, but only two of the most promising will be discussed here:

Scheme 1.--The use of comparatively large baffles to force a roller to form in front of the baffles, and additional baffles to step down the water surface from the high levels immediately above the large baffles to the tail-water elevation.

Scheme 2.--The use of blocks distributed over the entire apron to produce turbulence of the water with no intention of forming a significant roller or jump in this case.

Scheme 1

It was anticipated that baffles should be fairly large to force a roller to form with a shallow tail-water depth. A single row of baffle blocks 5 feet high, 3 feet 9 inches wide, and spaced 2 feet 11 inches apart was first tried (Arrangement 1, Figure 9). These baffles did not come up to expectations, as can be inferred from Photograph 10-A. The water was thrown up and over the large baffle blocks instead of forming a jump.

The baffles were then increased to 7.5 feet in height with the same width and spacing as in the previous test. One row of baffle blocks was again used, positioned on the apron as shown in Arrangement 2, Figure 9. These blocks produced less disturbance than the former, as can be observed from the photograph on Figure 10-B.

Next, an additional row of baffles 5 feet in height, staggered with respect to the first row of 7.5-foot blocks, was installed as shown in Arrangement 3, Figure 9. Figure 11-A shows some improvement over Arrangement 2, but the downsweep, as water passed over the large baffles, was little better than the former arrangement with the single row of large baffles. A plot showing the scour after a 1-hour run at a discharge of 20,000 cfs is included as Figure 12. The maximum depth of scour in this case was 7.5 feet.

The next test was made with the same baffle arrangment except that a triangular sill was placed on the end of the apron as shown for Arrangement 4, Figure 9. Photograph 11-B shows the action at a discharge of 20,000 cfs. There was no visual improvement in overall performance. The ground roller was strengthened by the triangular sill, however, and its effect can be observed from the plot showing scour after a discharge of 20,000 cfs (Figure 13). A comparision of Figures 12 and 13 shows more scour with the end sill installed, a maximum of 9 feet compared with 7.5 feet without the triangular end sill.

Scheme 2

The object of Scheme 2 was to distribute smaller blocks over the entire apron length. In this connection, three rows of cubes 3 feet 9 inches on a side, with a 3-foot 9-inch spacing, were placed on the apron as shown in Arrangement 5, Figure 14. The jet of water was thrown up and over the second row of blocks for a discharge of 20,000 cfs, with little dissipation of energy, as can be observed from Figure 15-A. This indicated that the front row of blocks should be smaller than the others.

In the next test five rows of blocks, varying in height from 1 foot 10-1/2 inches at the upstream end to 3 feet 9 inches at the downstream end, were placed over the entire apron as shown in Arrangement 6, Figure 14. The action at 20,000 cfs, which is much improved over any arrangement tried, is shown on Figure 15-B. A plot of the scour downstream from the apron, which shows a maximum depth of 8.3 feet, is plotted on Figure 16. This was by far the best arrangement tried to date. The water surface was quite regular, lacking the secondary jumps and rollers in the former tests. There was no apparent roller or jump, but the mixing action in the wake of each block was effective in dissipating energy.

An additional set of smaller blocks was finally installed upstream from the first row at elevation 156. These were found ineffective in improving the energy dissipation. They also proved detrimental in that they produced a backwater effect, causing the conduits leading from the gates to flow full.

CONCLUSIONS

At this point in the testing, official word was received that the Army had decided to abandon operations at Imperial Dam, and plans for revision of the stilling basin apron were canceled. Testing was therefore discontinued on the basis that Arrangement 6 shown on Figures 14 and 15-B was adequate and little improvement was expected from further testing. This arrangement is recommended as a satisfactory and economical method for revision which will allow intermittent flows of 20,000 cfs to be passed without endangering the structure.

The settling basin was repaired, but the stilling pool apron required no repairs for normal sluicing operations. Replacing of riprap downstream from the apron, however, should be done. It may be possible to postpone this operation until deposition of river sediment, by low discharges through the sluiceway, has time to partially refill the large hole. Should the Army return at a future date, revision of the stilling pool apron will be a necessity.

Interior - Reclamation - Denver, Colo.

FIGURE 1

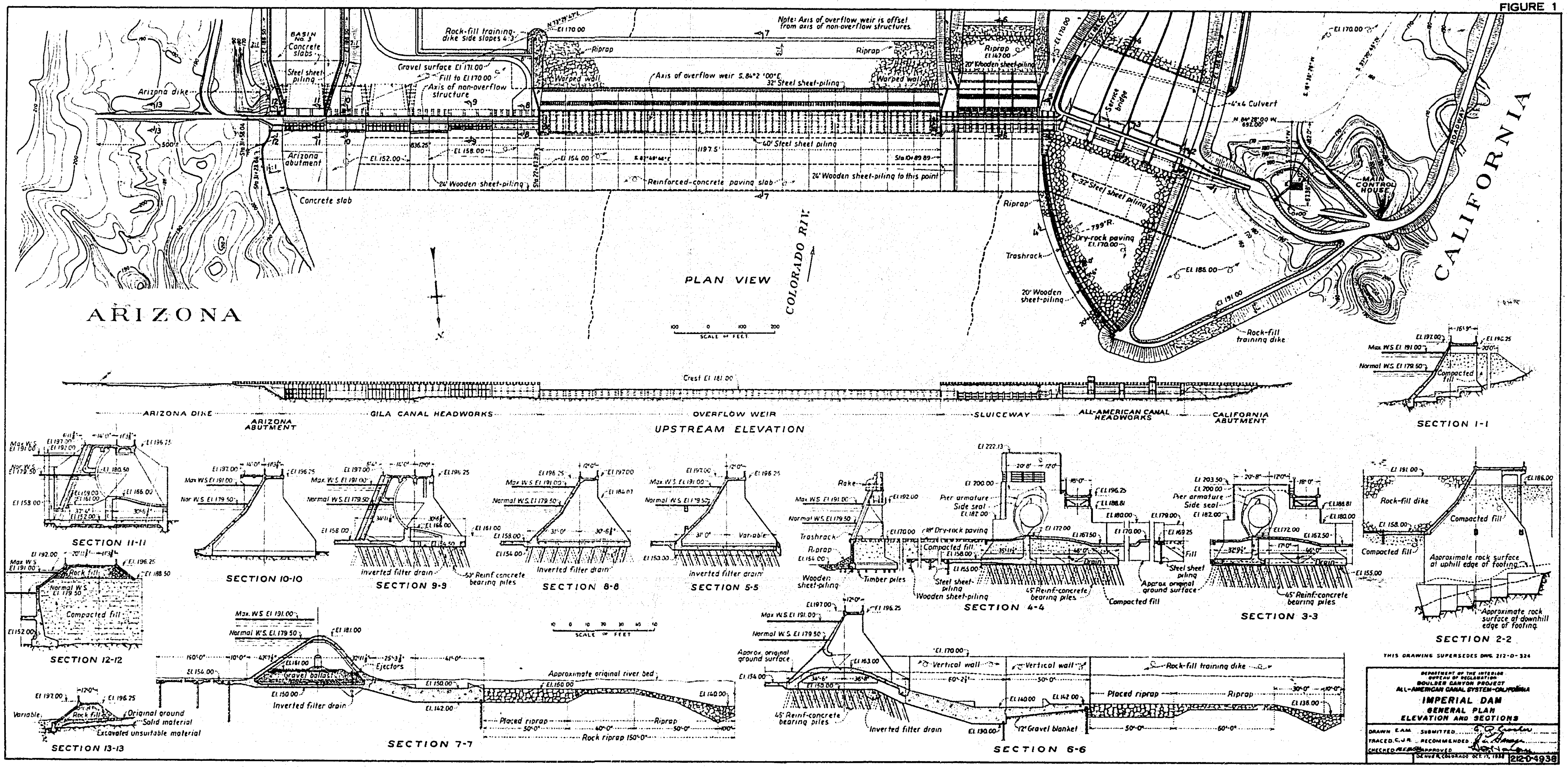
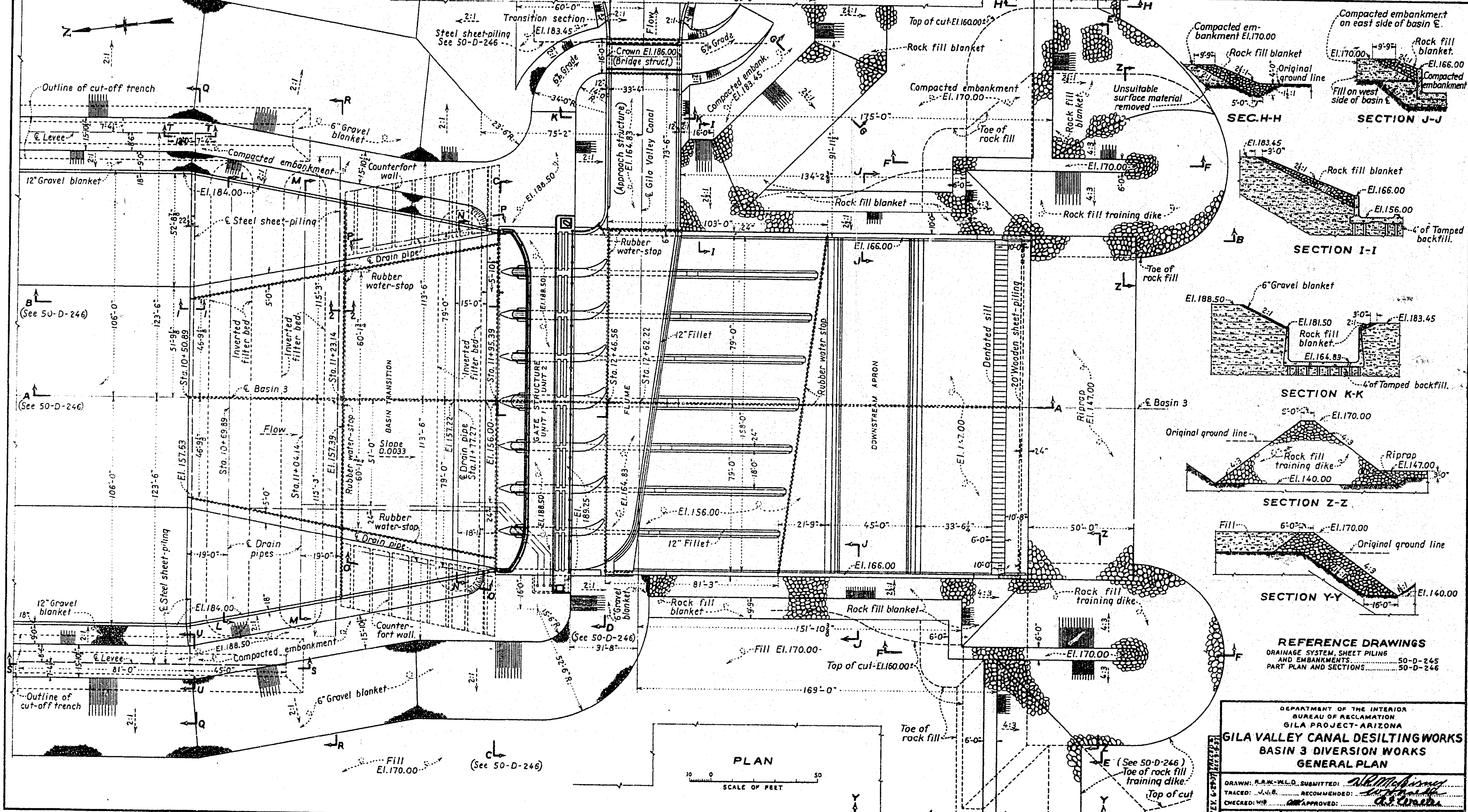
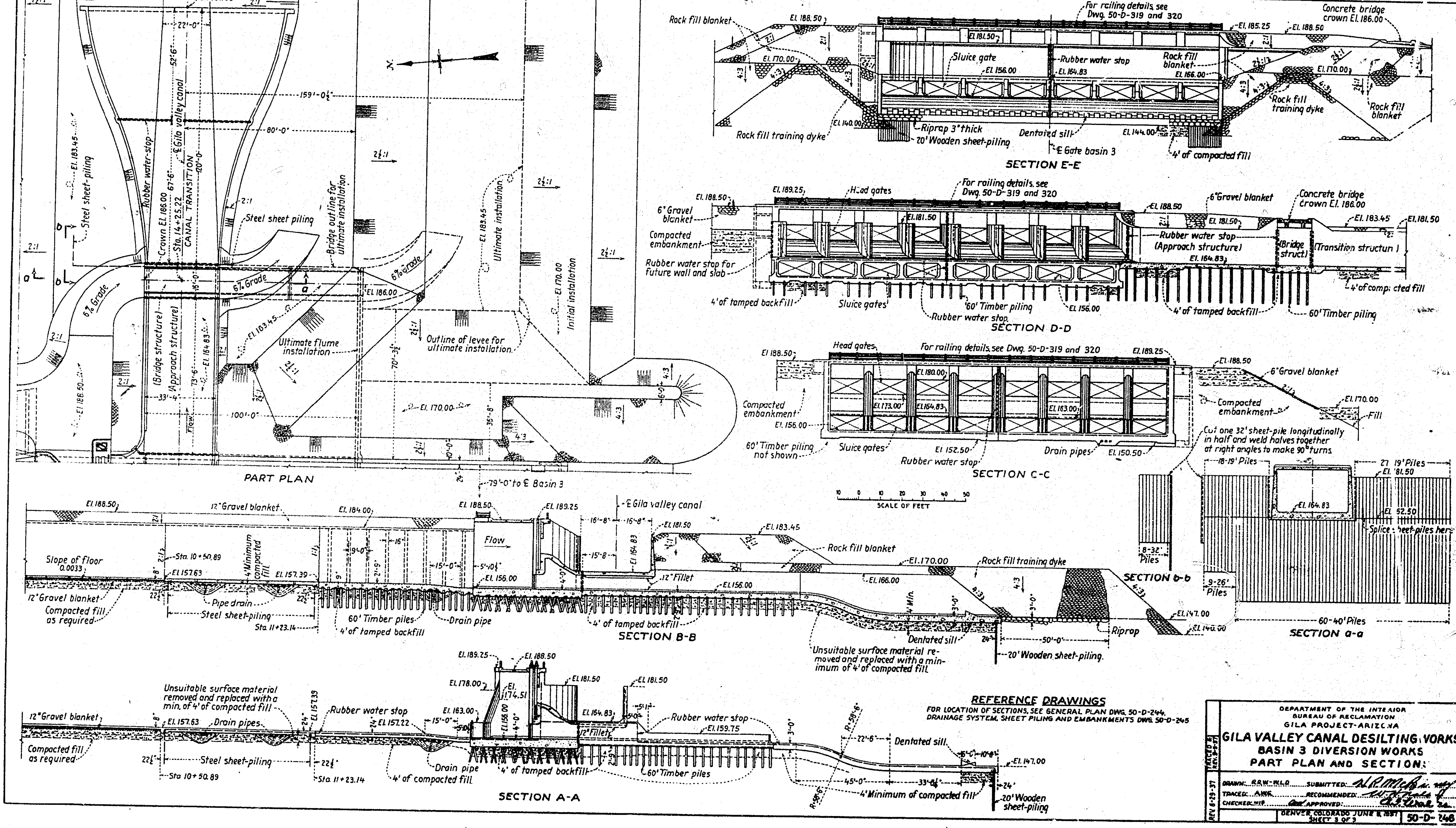

ARIZONA
CALIFORNIA
PLAN VIEW
COLORADO RIV.
Arizona dike
Arizona abutment
Concrete slab
BASIN No. 3
Concrete slabs
Steel sheet-piling
Rock-fill training dike side slopes 4:3
Gravel surface El. 171.00
Fill to El. 170.00
Axis of non-overflow structure
Riprap
Warped wall
Axis of overflow weir S. 84°2'00"E.
32' Steel sheet-piling
40' Steel sheet piling
24' Wooden sheet-piling
Reinforced-concrete paving slab
24' Wooden sheet-piling to this point
Note: Axis of overflow weir is offset from axis of non-overflow structures.
20' Wooden sheet-piling
Service bridge
4'x4' Culvert
MAIN CONTROL HOUSE
ROADWAY
Trashrack
Dry-rock paving El. 170.00
Rock-fill training dike
Crest El. 181.00
ARIZONA DIKE
ARIZONA ABUTMENT
GILA CANAL HEADWORKS
OVERFLOW WEIR
SLUICEWAY
ALL-AMERICAN CANAL HEADWORKS
CALIFORNIA ABUTMENT
UPSTREAM ELEVATION
SECTION 1-1
SECTION 11-11
SECTION 10-10
SECTION 9-9
SECTION 8-8
SECTION 5-5
SECTION 4-4
SECTION 3-3
SECTION 2-2
SECTION 12-12
SECTION 13-13
SECTION 7-7
SECTION 6-6
Inverted filter drain
50' Reinf. concrete bearing piles
45' Reinf.-concrete bearing piles
Compacted fill
Rock-fill dike
Approximate rock surface at uphill edge of footing
Approximate rock surface at downhill edge of footing
Original ground
Solid material
Excavated unsuitable material
Gravel ballast
Ejectors
Approximate original river bed
Placed riprap
Rock riprap 150'-0"
Vertical wall
12" Gravel blanket
THIS DRAWING SUPERSEDES DWG. 212-D-324
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BOULDER CANYON PROJECT
ALL-AMERICAN CANAL SYSTEM-CALIFORNIA
IMPERIAL DAM
GENERAL PLAN
ELEVATION AND SECTIONS
DRAWN E.A.M. SUBMITTED
TRACED C.J.R. RECOMMENDED
CHECKED APPROVED
DENVER, COLORADO OCT. 17, 1938
212-D-4938

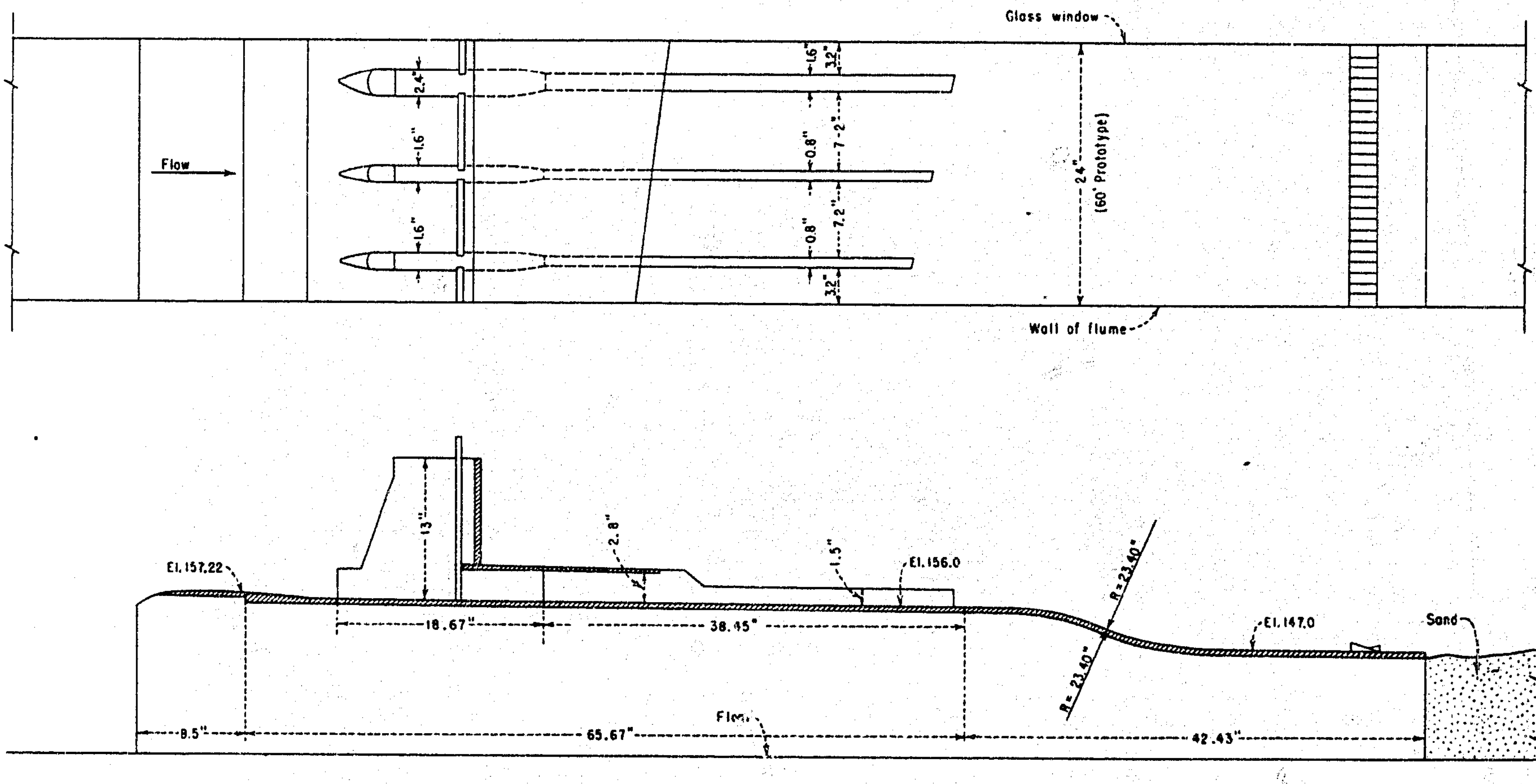
FIGURE 2



PLAN
SCALE OF FEET
SEC. H-H
SECTION J-J
SECTION I-I
SECTION K-K
SECTION Z-Z
SECTION Y-Y
GATE STRUCTURE
BASIN TRANSITION
FLUME
DOWNSTREAM APRON
Gila Valley Canal
(Approach structure)
Crown El. 186.00 (Bridge struct.)
Transition section
Steel sheet-piling See 50-D-246
Outline of cut-off trench
Compacted embankment
Rock fill blanket
Rock fill training dike
Dentated sill
20' Wooden sheet-piling
Riprap El. 147.00
Basin 3
Inverted filter bed
Rubber water-stop
Drain pipe
Counterfort wall
6" Gravel blanket
12" Gravel blanket
Fill El. 170.00
Top of cut-El. 160.00±
Toe of rock fill
REFERENCE DRAWINGS
DRAINAGE SYSTEM, SHEET PILING AND EMBANKMENTS 50-D-245
PART PLAN AND SECTIONS 50-D-246
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
GILA PROJECT-ARIZONA
GILA VALLEY CANAL DESILTING WORKS
BASIN 3 DIVERSION WORKS
GENERAL PLAN
DRAWN: R.R.W.-W.L.O. SUBMITTED:
TRACED: J.J.B. RECOMMENDED:
CHECKED: W.P. APPROVED:
DENVER, COLORADO-JUNE 8, 1937 SHEET 1 OF 2
50-D-244

FIGURE 3

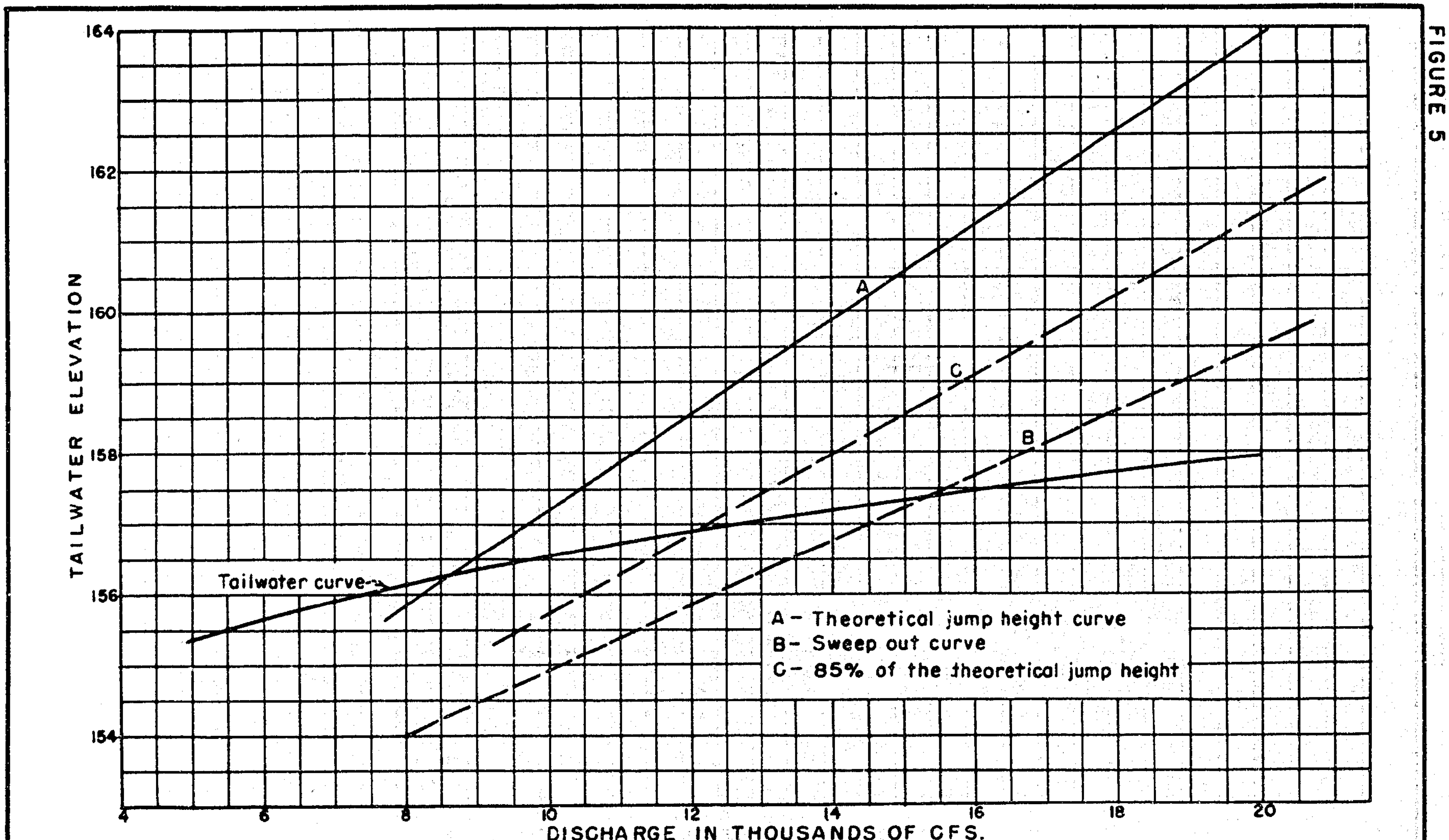

PART PLAN
SECTION E-E
SECTION D-D
SECTION C-C
SECTION B-B
SECTION A-A
SECTION b-b
SECTION a-a
SCALE OF FEET
Rock fill blanket
Rock fill training dyke
Sluice gate
Rubber water stop
Riprap 3" thick
20' Wooden sheet-piling
Dentated sill
℄ Gate basin 3
4' of compacted fill
Concrete bridge crown El. 186.00
For railing details see Dwg. 50-D-319 and 320
Head gates
6" Gravel blanket
Compacted embankment
Rubber water stop for future wall and slab
4' of tamped backfill
Sluice gates
60' Timber piling
Rubber water stop (Approach structure)
(Bridge struct.)
(Transition structure)
60' Timber piling not shown
Drain pipes
Cut one 32' sheet-pile longitudinally in half and weld halves together at right angles to make 90° turns
Splice sheet-piles here
Steel sheet piling
Rubber water-stop
℄ Gila valley canal
CANAL TRANSITION
(Bridge structure)
(Approach structure)
Bridge outline for ultimate installation
Ultimate flume installation
Outline of levee for ultimate installation
Ultimate installation
Initial installation
6% Grade
79'-0" to ℄ Basin 3
12" Gravel blanket
Slope of floor 0.0033
4' Minimum compacted fill
Compacted fill as required
Pipe drain
Steel sheet-piling
60' Timber piles
Drain pipe
12" Fillet
Unsuitable surface material removed and replaced with a minimum of 4' of compacted fill
Unsuitable surface material removed and replaced with a min. of 4' of compacted fill
4' of compacted fill
4' Minimum of compacted fill
20' Wooden sheet-piling
REFERENCE DRAWINGS
FOR LOCATION OF SECTIONS, SEE GENERAL PLAN DWG. 50-D-244.
DRAINAGE SYSTEM, SHEET PILING AND EMBANKMENTS DWG. 50-D-245
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
GILA PROJECT-ARIZONA
GILA VALLEY CANAL DESILTING WORKS
BASIN 3 DIVERSION WORKS
PART PLAN AND SECTIONS
DENVER, COLORADO JUNE 8, 1937
SHEET 3 OF 3
50-D-246



GILA VALLEY DESILTING WORKS
SCHEMATIC DRAWING OF SECTIONAL MODEL
SCALE = 1:30

FIGURE 4

413

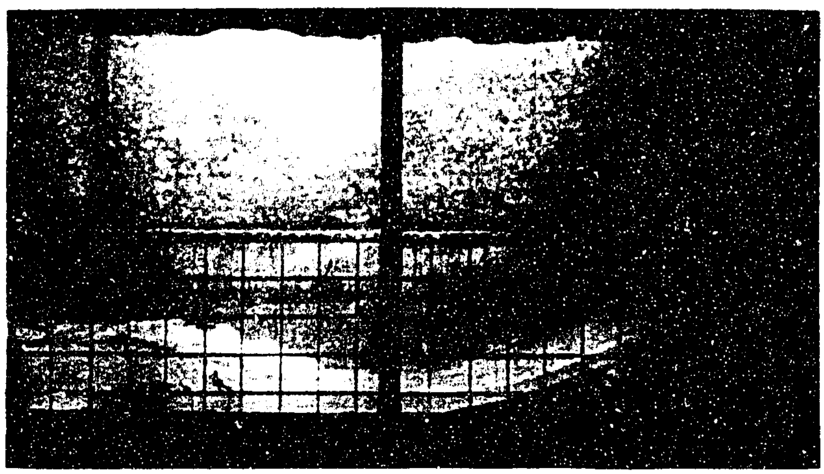


GILA VALLEY DESILTING WORKS
SLUICEWAY STILLING BASIN TAILWATER CURVE

413

FIGURE 6

A Discharge 8,000 Second-Feet



B Discharge 12,000 Second-Feet

SLUICEWAY STILLING POOL - GILA VALLEY DESILTING WORKS

EXISTING STRUCTURE

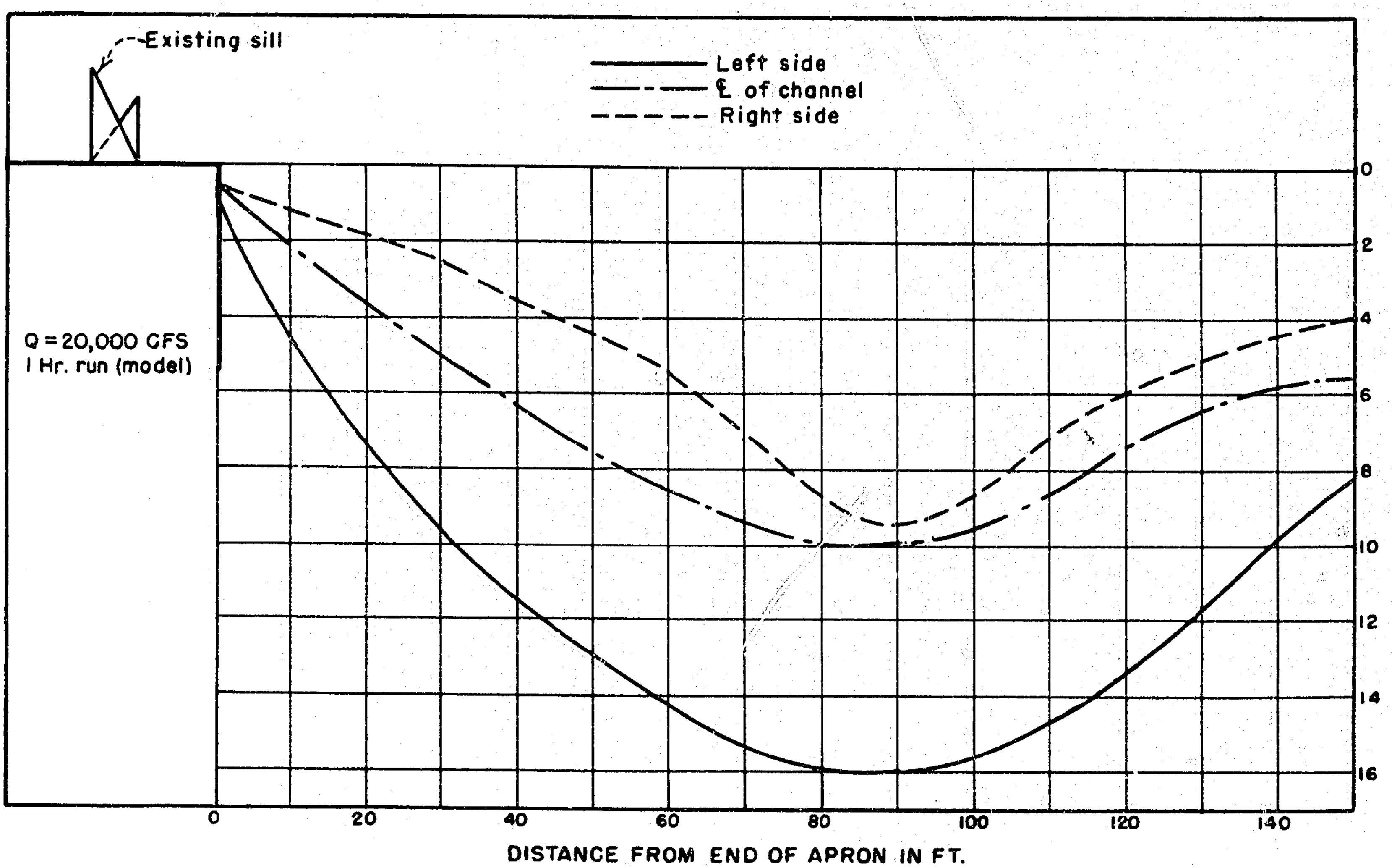
FIGURE 7

A Discharge 16,000 Second-Feet

B Discharge 20,000 Second-Feet

SLUICEWAY STILLING POOL - GILA VALLEY DESILTING WORKS

EXISTING STRUCTURE

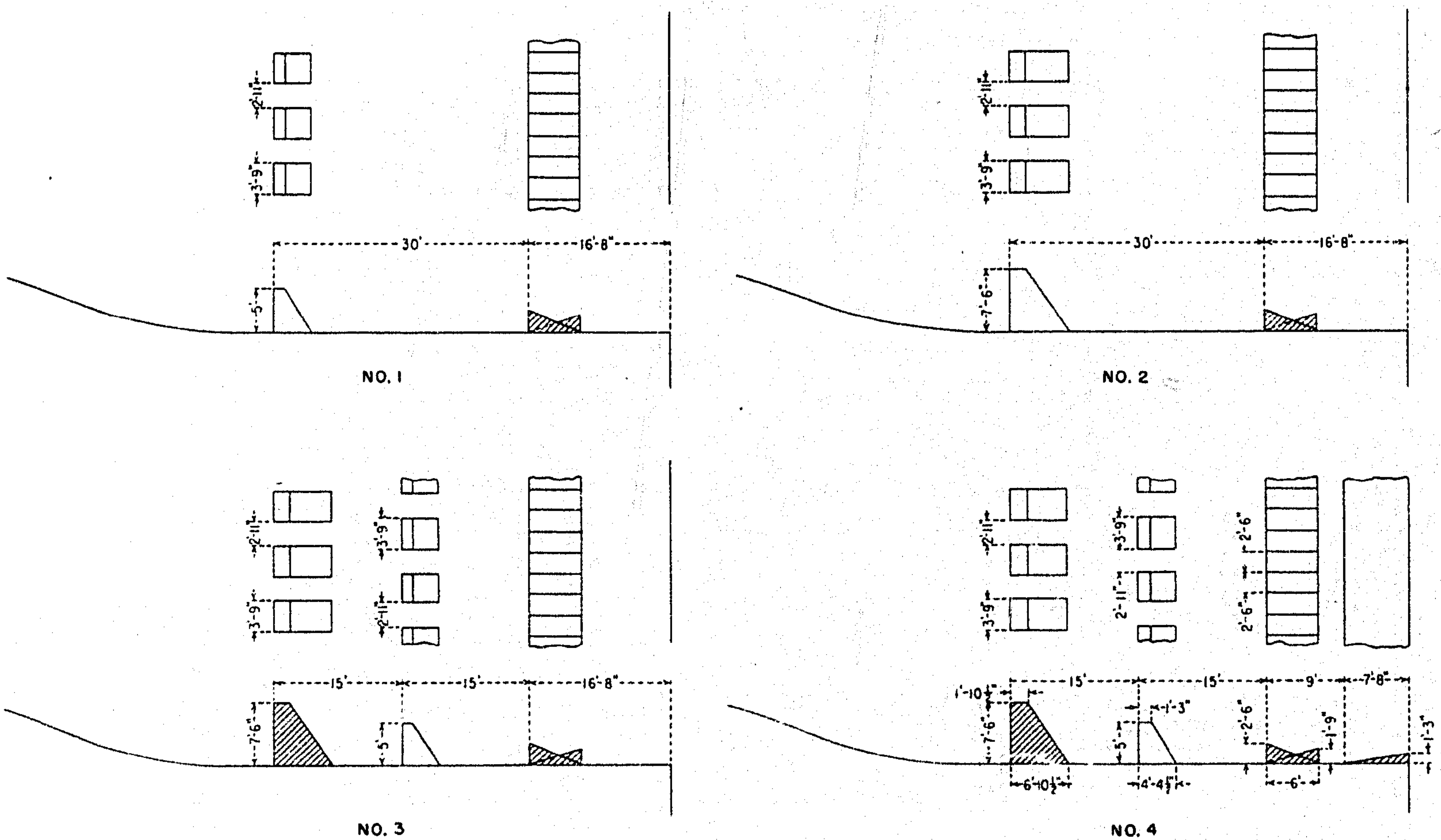


GILA VALLEY DESILTING WORKS
SCOUR PROFILES DOWNSTREAM FROM EXISTING APRON

413

FIGURE 8

FIGURE 9

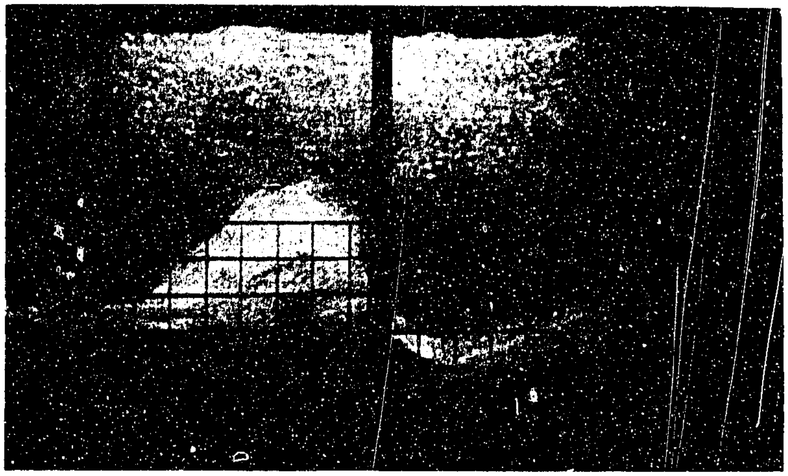


GILA VALLEY DESILTING WORKS

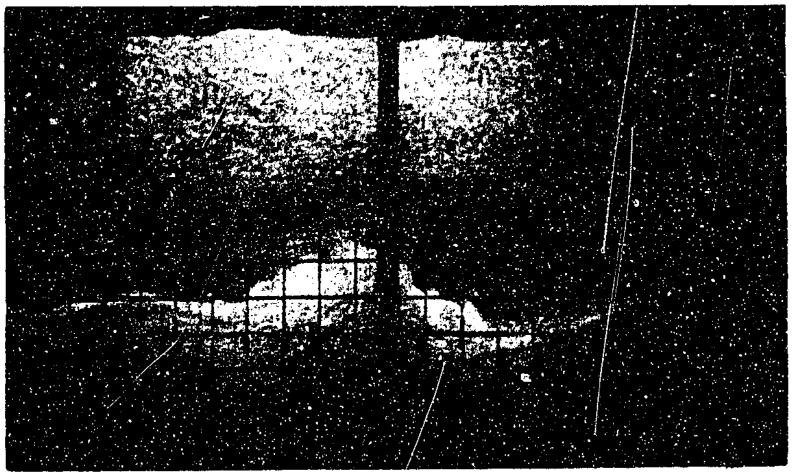
BAFFLE BLOCK ARRANGEMENTS ON STILLING BASIN APRON

413

FIGURE 10



A One Row of Baffle Blocks 5 feet high
Discharge 20,000 Second-Feet

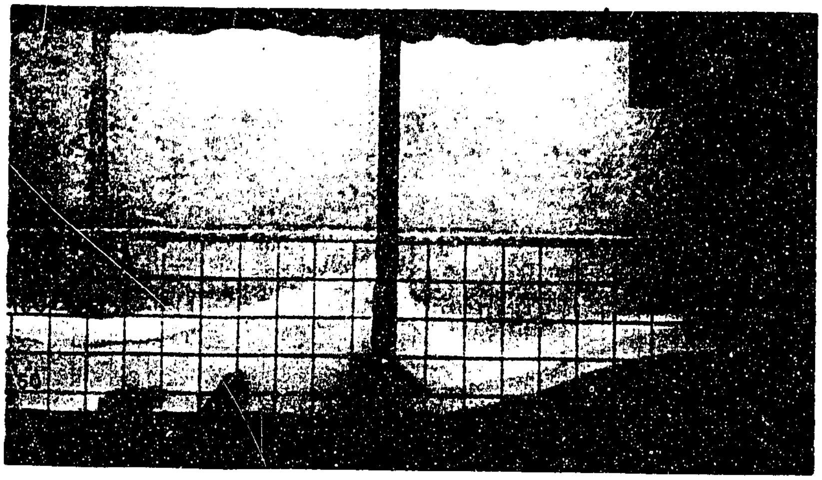


B One Row of Baffle Blocks 7.5 feet high
Discharge 20,000 Second-Feet

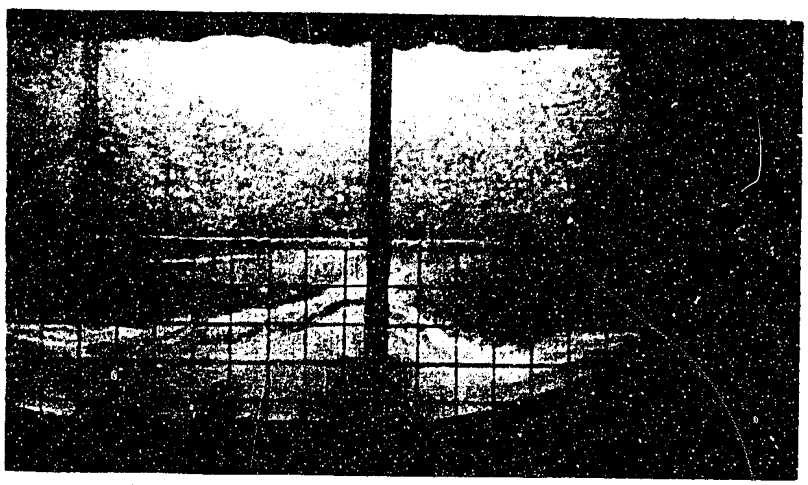
SLUICEWAY STILLING BASIN - GILA VALLEY DESILTING WORKS

SCHEME A

FIGURE 11



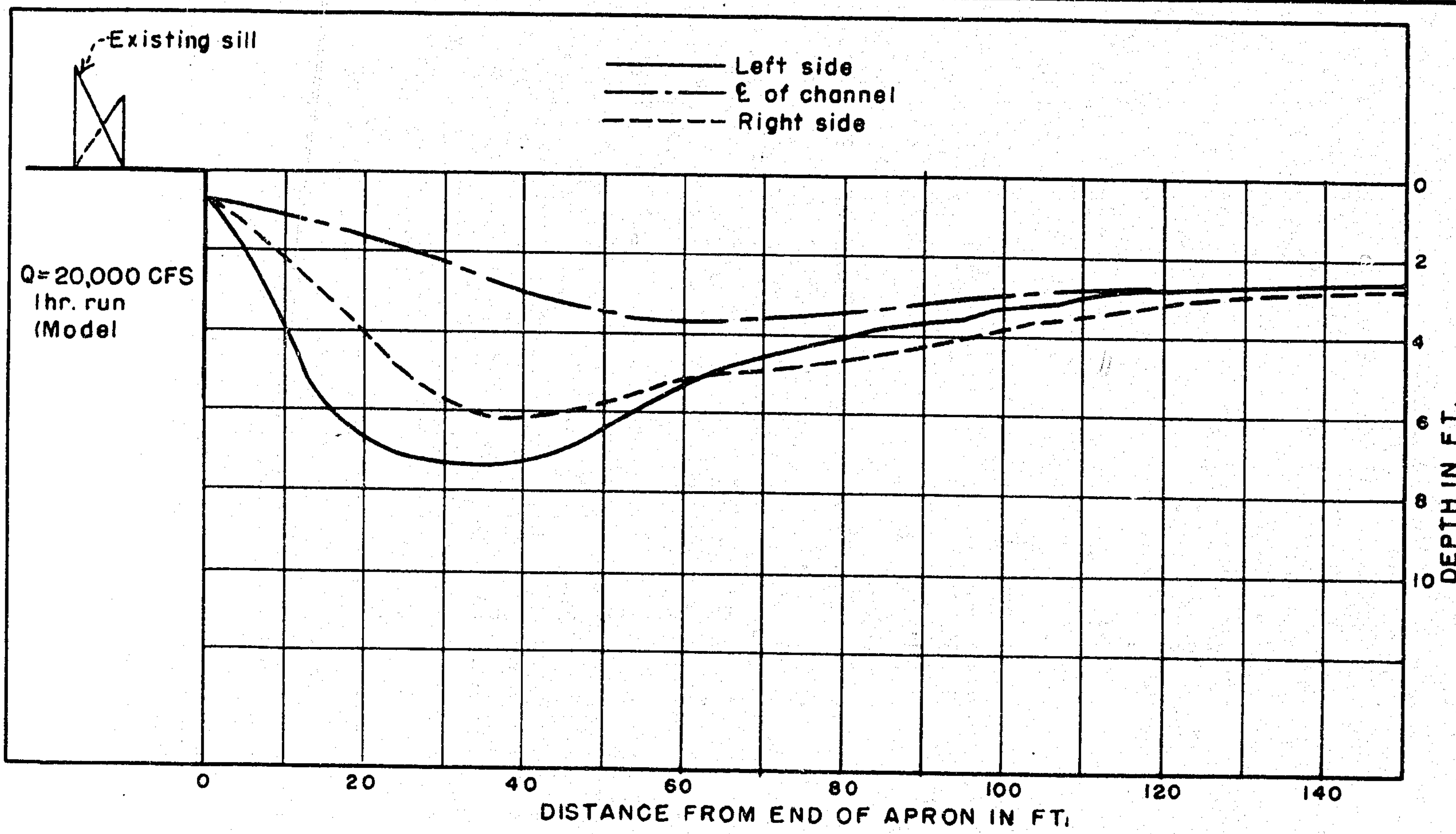
A Baffle Blocks 7.5 and 5.0 Feet High
Discharge 20,000 Second-Feet



B Baffle Blocks 7.5 and 5.0 Feet High and
Solid Triangular end sill
Discharge 20,000 Second-Feet

SLUICEWAY STILLING BASIN - GILA VALLEY DESILTING WORKS

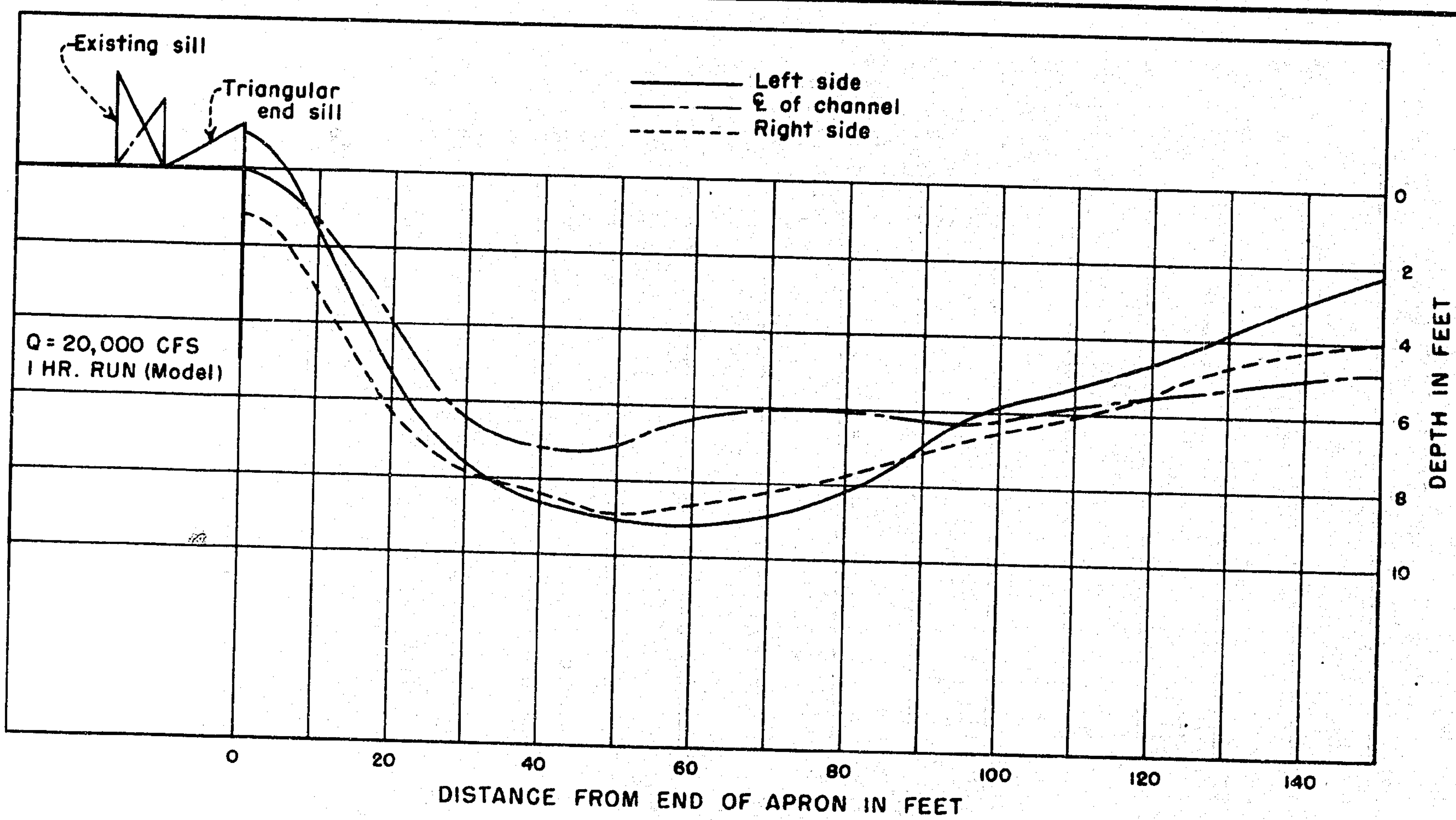
SCHEME A



GILA VALLEY DESILTING WORKS
SCOUR PROFILES DOWNSTREAM FROM APRON
USING BAFFLE ARRANGEMENT NO. 3

413

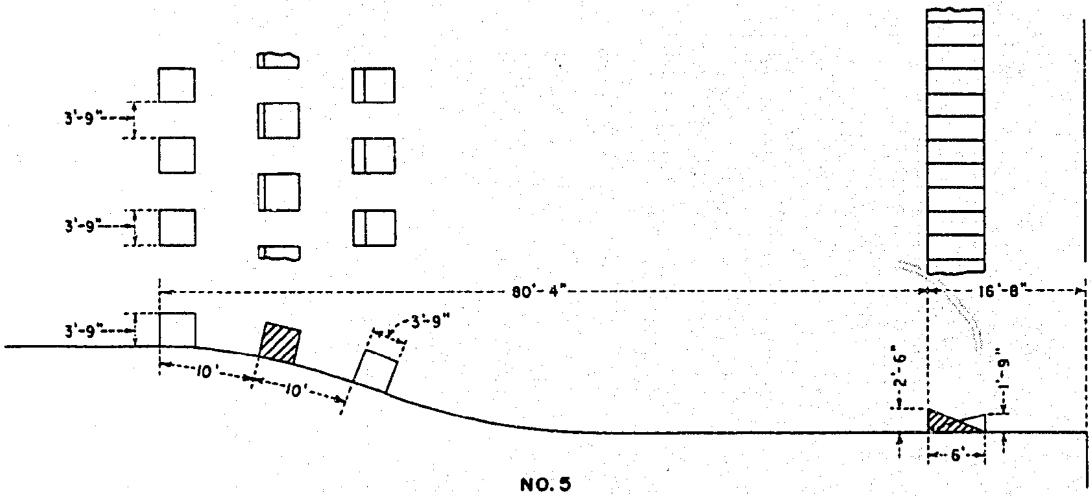
FIGURE 12



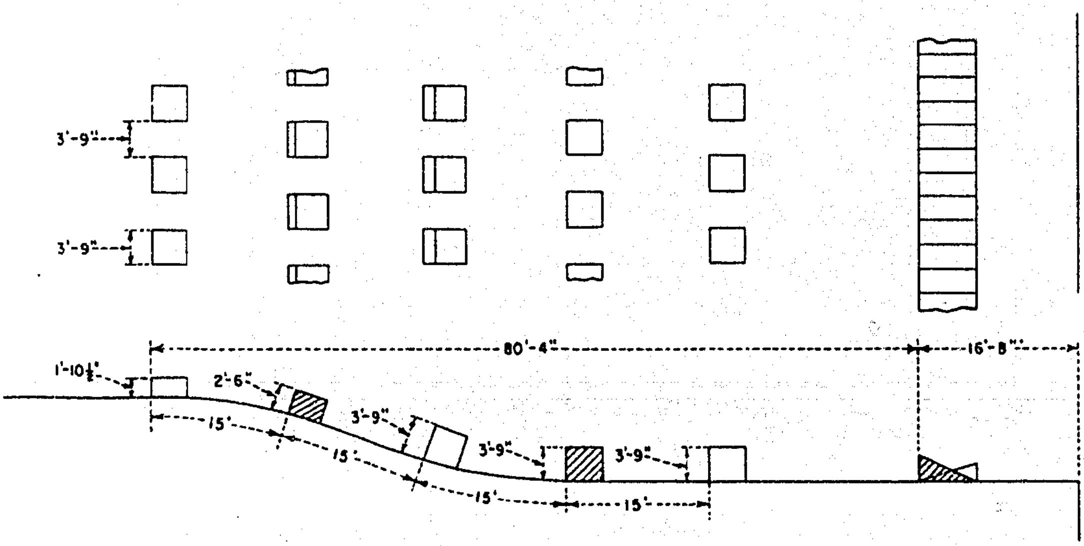
GILA VALLEY DESILTING WORKS
SCOUR PROFILES DOWNSTREAM FROM APRON USING BAFFLE ARRANGEMENT NO. 4 WITH A TRIANGULAR END SILL

FIGURE 13

413



NO. 5



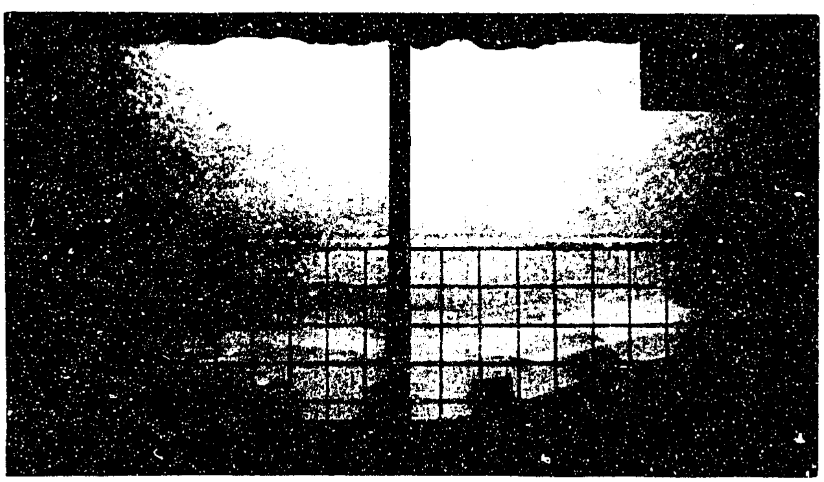
NO. 6

GILA VALLEY DESILTING WORKS

BAFFLE BLOCK ARRANGEMENTS ON STILLING BASIN APRON

FIGURE 15

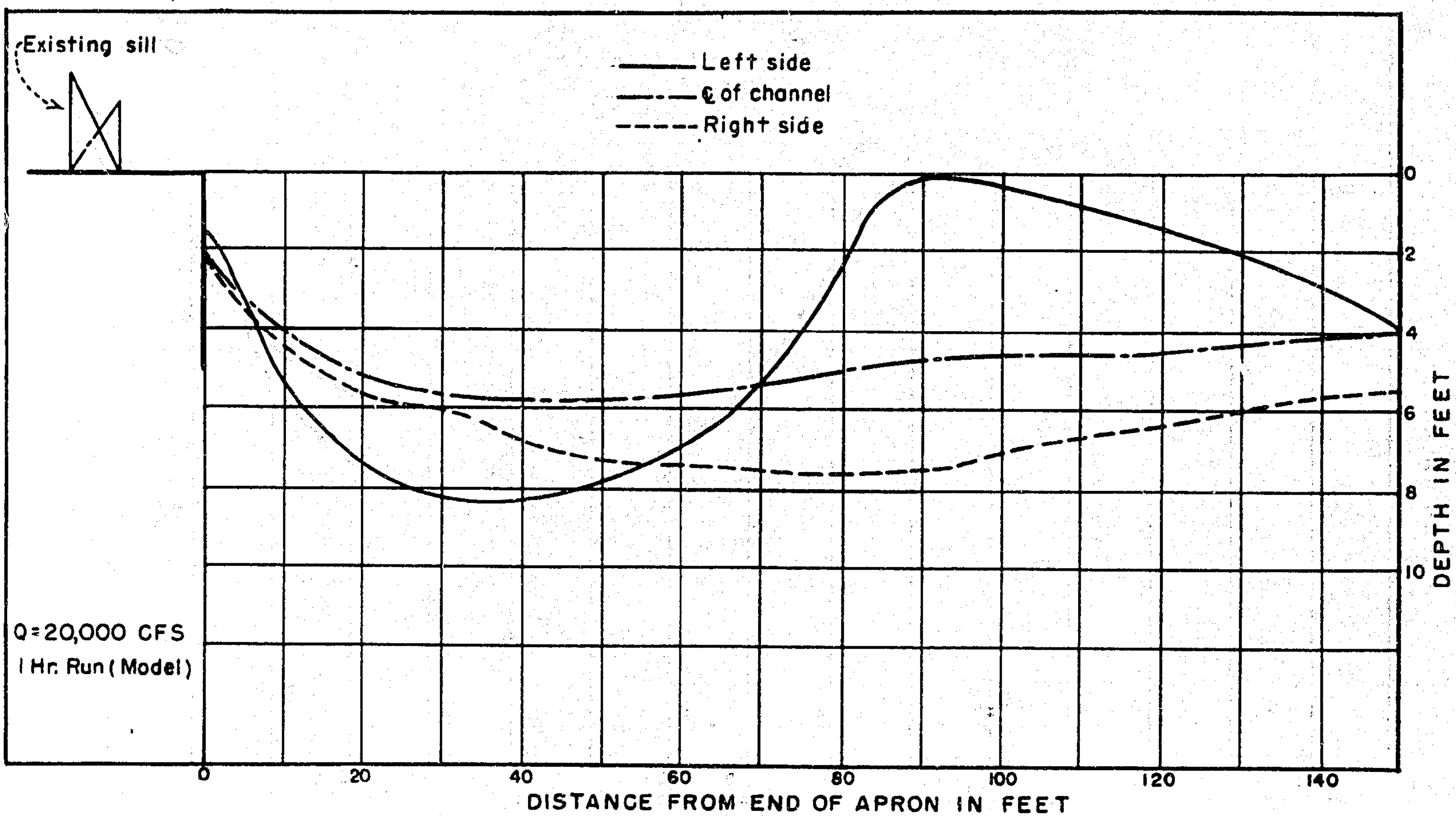
A Three Rows of Blocks 3.75 feet high
Discharge 20,000 Second-Feet



B Five Rows of Blocks 1.875 to 3.75 Feet High
Discharge 20,000 Second-Feet
RECOMMENDED DESIGN

SLUICEWAY STILLING POOL - GILA VALLEY DESILTING WORKS

SCHEME B



GILA VALLEY DESILTING WORKS
SCOUR PROFILES DOWNSTREAM FROM APRON
USING BAFFLE ARRANGEMENT NO. 6

413

FIGURE 16